Before the
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C. 20554

In the Matter of:	)
	)
A National Broadband Plan for Our Future-	) **GN Dockets No. 09-47,09-51, 09-137**
"Research Necessary for Broadband	)
Leadership"	)
	)
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COMMENTS –NBP PUBIC COMMENT #22

TELCORDIA TECHNOLOGIES

Telcordia Technologies (Telcordia) hereby submits comments to the Federal Communications Commission (FCC or "Commission") on its Public Notice requesting Comments on "Research Necessary for Broadband Leadership" in the above-captioned proceeding.[1] The Notice seeks comments on the development of research recommendations for Congress to enable the United States to advance to be a global leader in broadband networking in the years 2020 and beyond.

BACKGROUND

Telcordia is a software and engineering and consulting company with a vested interest in expanding the deployment of broadband. Telcordia, formerly known as Bell Communications Research (Bellcore), was created in 1984 at the time of the AT&T divestiture as a unique entity with a mission to provide common R&D as well as

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[1] Public Notice, National Broadband Plan –"Research Necessary for Broadband Leadership", GN Dockets No. 09-47,09-51,09-137, Public Notice DA 09-2434, Released November 18, 2009.

technology generic requirements and seamless operational capabilities across all the new service provider boundaries. We have the depth and breadth of telecommunications experience to handle the full spectrum of broadband and information network engineering and design issues. We offer the following comments on the issues raised by the Commission.

EXECUTIVE SUMMARY

Ensuring America's competitiveness in the 21st century requires a broadband telecommunications infrastructure that is secure, scalable, evolvable, trusted, robust, interoperable, affordable, inclusive, fault-tolerant, easy to use, and easy to maintain. Information and Communications Technology (ICT) and broadband networking drive all aspects of the U.S. economy, from education, healthcare, transportation, public safety, and energy to commerce, manufacturing, government, entertainment, science and engineering. The underlying capabilities that drive ICT and broadband networking are evolving rapidly, creating significant challenges to cost-effectively achieve the roadmap of our National Broadband Plan.

Meeting these challenges requires a *balanced*, *coordinated* and *strategically directed* R&D investment of adequate *size* and *scope*. To achieve value and avoid bottlenecks, innovations must proceed in a balanced fashion:

- Across the key dimensions of CapEx, OpEx, Services, and Adopters, so that underlying network capability is available to deliver new services and that new adopters can be supported efficiently (see Figure 1, page 7);

- Across the services value chain or, perhaps better, the services value web, which includes the totality of organizations and market segments that design, develop, deploy, and operate information networking technology: from physical components, devices, and equipment; to network systems, services, management, and operations; to content, media, storage, and applications; and to management and assurance of content, identity, and security (see Figure 2, page 8);

- Across the lifecycle phases of R&D from basic and applied research to systems, management, and operational capability so that the nation reaps the rewards of research by getting better and more affordable services in the hands of a wider range of citizens and businesses, regardless of their ability, geography, or industry (see Figure 3, page 9); and,

- Across the short, medium and long term so that we solve not only the problems of today, but also lay the groundwork for breakthrough innovations in the longer term; there are a number of specific challenges in the current environment for initiating and sustaining long-term, high-risk research projects with uncertain but promising -- and perhaps revolutionary -- potential.

To target the most important problems and opportunities and to achieve rapid and successful technology transfer and commercialization, *leadership* and *coordination* are required among R&D funders and performers, both public and private. Stronger and more strategic leadership is necessary to avoid fragmentation, duplication of effort, and a preponderance of incremental research. Given the dynamic, complex and heterogeneous structure of the broadband industry, coordination is needed to accelerate the impact of

R&D by facilitating technology transfer and knowledge transfer within the broadband industry and related industries. Technology transfer and commercialization are not straightforward one-way processes of making sure that downstream organizations can implement and deploy new technologies; rather they are multi-directional activities that also ensure real-world knowledge informs all types of research, from basic to applied. We propose a new Center for Broadband and Information Networking R&D which would provide leadership and coordination among the following key constituencies:

- Businesses, from large, well-established firms to small startups, in all areas of the industry;

- Universities, academics and other educators;

- Standards organizations and industry groups;

- Government at all levels, federal, regional, state, local, and municipal;

- Foundations and other NGOs active in ICT and digital inclusion; and

- Energy, transportation, media, construction and other closely related industries.

To achieve international leadership in broadband, more funding and investment are needed to adequately address the scale and scope of challenges and opportunities. Specifically, we recommend:

- Increase the amount of federal funding for networking and information technology R&D;[2]

- Expand the R&D tax credit to a multi-year program with provisions for a graduated credit which provides incentive for companies to increase both the size

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[2] Per http://www.nitrd.gov/pubs/2010supplement/FY10Supp-FINALFormat-Web.pdf, the 2009 NITRD budget was $3.9B which is only a few percent of the total 2009 federal R&D budget.

of their total R&D effort in the U.S. and the fraction of the effort which addresses basic research and high-risk projects;[3]

- Create and federally fund a Center for Broadband and Information Networking R&D which will oversee and manage the research portfolio;

- Direct investment into the critical and 'gap' areas through judicious choice of funding vehicles;

- Invest strategically to achieve breakthroughs in functionality, cost, security, usability, and scale;

- Actively coordinate and integrate research efforts across the public and private sector and across ICT and key industries including energy, transportation, public safety, healthcare, government, and education; and,

- Support science and engineering to develop the human resources to create innovations.

In the remainder of this Comment we provide additional discussion on the points above. We conclude with our 'baker's dozen' list of 13 priority areas for R&D.

DISCUSSION

Broadband Research Environment

The National Broadband Plan will provide a roadmap to building the telecommunications infrastructure needed for America's competitiveness in the 21st century. Broadband communications and information technology underpin all sectors of

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[3] See this web memo from The Information Technology and Innovation Fund for more information (http://www.itif.org/index.php?id=319).

our economy and their advancement is critical to our national growth and productivity. To paraphrase a recent report by the National Academy of Engineering[4], information and communications technology (ICT) "has transformed, and continues to transform, all aspects of our lives: commerce, education, employment, health care, manufacturing, government, national security, communications, entertainment, science, and engineering. [ICT] also helps drive the economy — both directly (the [ICT] sector itself) and indirectly (other sectors that are powered by advances in [ICT])." The underlying capabilities that comprise the ICT industry and our broadband infrastructure are evolving at a very fast rate, creating a number of significant challenges that must be met to cost-effectively realize the roadmap to our National Broadband Plan.

Fundamentally, research and development aims to do things 'faster, cheaper, better' through the creation and improvement of concepts, techniques, processes, methodologies, tools, and processes. It is critical that advancements be *balanced* to avoid roadblocks and ensure that the benefits of the innovations can be achieved. One dimension that requires balance is the four areas depicted in Figure 1: capital expense (CapEx), operations expense (OpEx), services / capabilities, and adopters. All four areas advance evenly as they are interdependent – for example, to reduce the cost of deploying and supporting more complex services and applications, innovation is required to lower the cost of the associated network infrastructure and operations.

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[4]National Academy of Engineering, Assessing the Impacts of Changes in the IT R&D Ecosystem: Retaining Leadership in an Increasingly Global Environment, 2009.

CapEx	OpEx	Services	Adopters
•Lower production costs for network equipment and devices •Decrease time frame and expense of installation (more automation) •Lengthen equipment replacement cycles •Improve fundamental capacity to meet core network demands	•Improve scalability •More adaptable systems •Improve security & privacy •Autonomic operation for "lights-out" operation •More automated monitoring and alarming (less intervention required)	•Service creation platforms enabling rapid development and deployment of new services •More flexible services •Service portability (across networks and providers) •Better personalized services improving efficiency	•Improve ease-of-use to decrease time and expense of training •Expand usability of services and devices to support disabled users •Services aware of user "context" requiring less input from users •Machine-to-machine communications

Figure 1. R&D is Needed across these Areas to Develop the Innovation and Advancement Required to Achieve the National Broadband Plan

Balance is also needed across the service delivery chain (or better, "web"), which consists of the entities and market segments that comprise the industry (see Figure 2). The number of technology organizations involved in creating, deploying, and operating our broadband infrastructure and providing services and information is vast. Not all organizations have the same resources, incentives and capabilities for innovation. As the FCC notes in their Interim Report, "Rapid innovation in some sectors must not be limited by bottlenecks in others."[5] Broadband infrastructure is fundamentally complex as it involves many different capabilities, technologies, policies, devices, organizations, and processes working in concert. It is the breadth of critical areas and their myriad inter-dependencies that create both the challenge of advancing our broadband infrastructure and the promise of delivering substantial value by enabling a high-performance America.

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[5] FCC, "September Commission Meeting," http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-293742A1.pdf, September 29, 2009, p. 136.
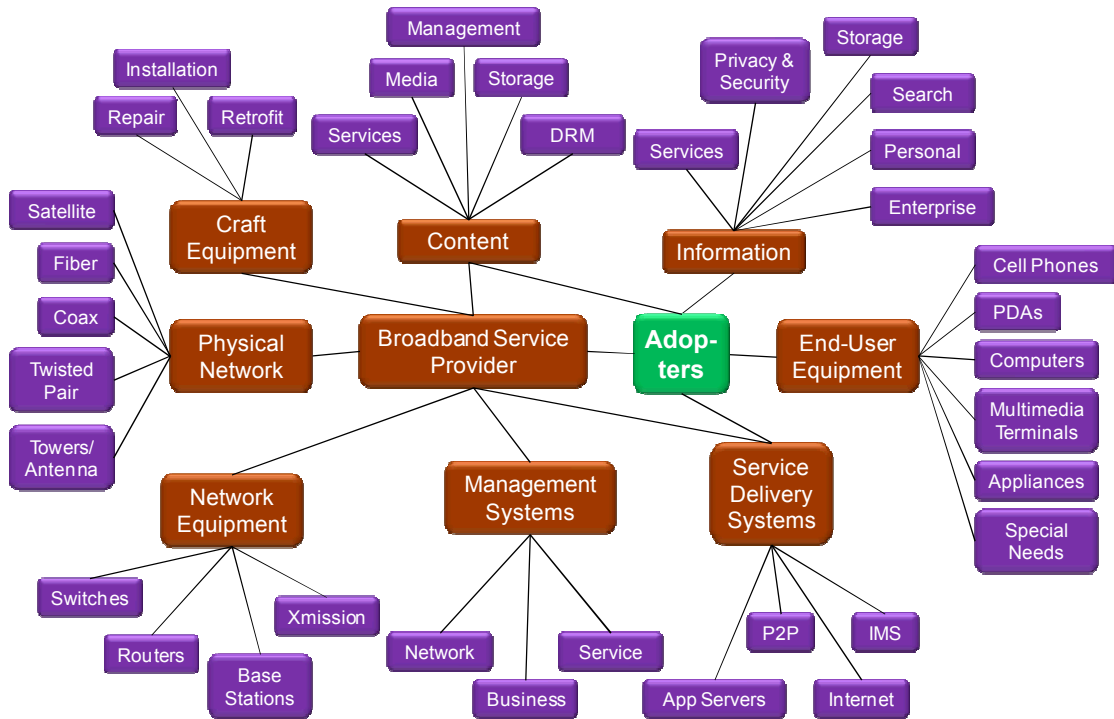
Figure 2. R&D Investment Must be Balanced across All the Entities that Contribute to the Development, Deployment, and Operations of Technology for Enabling and Delivering Information and Services over Broadband Network as Depicted in this Adopter Value Chain

To ensure that inventions are successfully deployed, balance must also be assured across the product and services lifecycle. The U.S. department of defense recognizes this and categorizes research and development activities into the seven phases[6] shown in Figure 3. This dimension of the R&D space is particularly critical for technology transfer and commercialization. Without appropriate investment in the latter phases, inventions, whether in end user devices, networking or applications, may fail to achieve widespread deployment due to excessive cost and difficulty in management and operations. In addition to ensuring that each phase receives adequate investment, it is also necessary to address interconnections and interfaces between phases and to implement feedback mechanisms among the various phases. Adequate R&D support is required along all of

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[6] *Beyond Sputnik: U.S. Science Policy in the Twenty-First Century* by Homer A. Neal, Tobin L. Smith, Jennifer B. McCormick, University of Michigan Press, 2008.

these phases to assure the transition of technology from discovery (in basic research) to deployment (in operational systems development). For example, if technology leapfrogs from the "Advanced Component Development and Prototypes" phase directly to "Operational Systems Development," issues related to scalability, performance, and efficient management may not be adequately addressed with negative impacts for the deployed system.
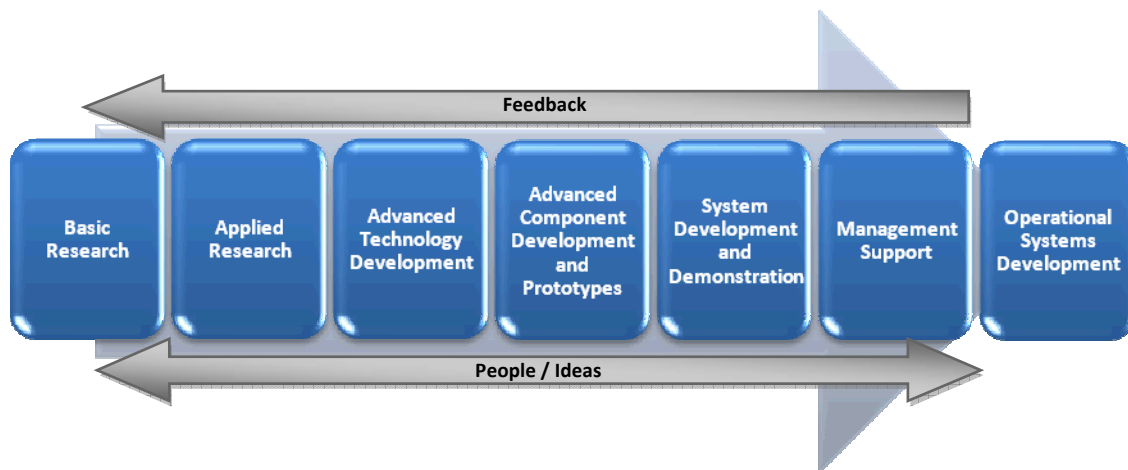

Figure 3. R&D Progresses (from left-to-right in the diagram) though Seven Phases in Order to Mature Basic Research into Real-World Deployable Systems

To deliver solutions to current near-term problems and also create breakthrough discoveries our national broadband research effort should comprise a balanced portfolio of projects that range from longer-term, higher risk projects to near-term, incremental projects. The research must also range from core technology areas such as security architectures and advanced wireless, to new and emerging topics. The portfolio will need to be regularly reviewed and rebalanced to ensure that it contains the proper mix of low risk projects and those projects that may deliver unexpected and/or major discoveries.

Proven techniques for portfolio management and gated decision-making[7] can be used to review projects at reasonable intervals. A gated process is particularly important for overseeing high-risk, high-reward projects.

Finally, we must also ensure that the fundamental research capability is available to implement the research program. This requires maintaining the strength in our educational system for training engineers and scientists; sustaining the facilities and infrastructure in our colleges, universities, and industrial labs; and nurturing the talent pool to develop principal researchers who will have the creativity, vision, and passion to generate breakthrough discoveries now and in the future.

Funding, Leadership, and Coordination

Given the criticality of broadband information networking to all facets of our economy and society, the total level of funding must be adequate to address the full range of challenges and opportunities. Although numerous studies have shown the high gains in productivity from advances in ICT, only a few percent of the U.S. federal budget for R&D is spent on ICT and networking.[8] The United States invests a substantially smaller percent of resources in telecommunications and networking R&D compared with other parts of the world. For example, the European Union in its 7th Framework Program has made the ICT theme its single largest with over 9B Euro in funding.[9] Current U.S. investment levels in ICT and related content and information storage and retrieval

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[7] As described by Robert Cooper in *Winning at New Products* by Perseus Publishing, 2001.
[8] Per http://www.nitrd.gov/pubs/2010supplement/FY10Supp-FINALFormat-Web.pdf, the 2009 NITRD budget was $3.9B which is only a few percent of the total 2009 federal R&D budget.

[9] See http://cordis.europa.eu/fp7/ict/.

technologies are moderate at best, and are not necessarily directed at the most important problems and/or aligned with the long-term national broadband vision. ICT investment relative to the national GDP has remained flat since 2002 and venture capital investments in the communications technology sector have declined in the last two years.[10] Broadband networking is a competitive, global market and regaining a leadership position in this industry requires that it receive higher priority and a larger quantity of federal investment funds.

In addition to increasing the federal budget for broadband R&D, we strongly support an expansion of the R&D tax credit to encourage more investment by industry. The R&D tax credit is a proven mechanism for spurring discovery and, as Adrian Slywotzky wrote in a recent Business Week article, "Discovery drives innovation, innovation drives productivity, (and) productivity drives economic growth."[11]   We propose that the R&D tax credit be enhanced as follows to incent greater investment by firms active in all parts of the service delivery web:

- Multi-year program: Without the certainty of multi-year tax benefits, it is difficult for industry to embark on projects with a longer time horizon;

- Graduated: Increase the tax credit for companies that invest a higher fraction of their resources in R&D; and

- Preferential: Build in a preference for more exploratory (early-phase) R&D and for domestically-sourced R&D.

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[10] FCC, "September Commission Meeting," see http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-293742A1.pdf, September 29, 2009.
[11] Business Week, August 27, 2009, "Where Have You Gone Bell Labs?" by Adrian Slywotzky.

We are all aware that the United States does not lead globally in advanced telecommunications and information networking. As the Knight Center for Digital Excellence notes, "Our European and Asian counterparts have been investing in broadband robust enough to support new products and services, creating a test bed for innovation. This strategy is fostering and attracting companies seeking the 21st century infrastructure lacking in the U.S."[12] In many respects the U.S. has not had a leadership position since the industry re-structuring that led to the loss of AT&T's Bell Labs. The Bell Labs era was remarkable for the top-notch, large-size, tightly-knit, and vertically-structured research and engineering organization that developed and operated best-of-breed telecommunications and information networks. As one well-managed organization, Bell Labs researchers were able to deliver a balanced R&D effort which addressed all the areas and phases of R&D in an integrated fashion.

Today's information networking industry is dynamic, complex, varied, and dramatically changed from the days of Bell Labs. Re-creating a single, monolithic R&D entity for telecommunications, whether public or private, is neither logical nor advisable for meeting today's needs for innovation. A recent Business Week article titled "Where Have You Gone Bell Labs?" noted the following about the state of the U.S. technology industry, "The venture-capital and initial public offering components … are still in place; we just have to rebuild the upstream labs that focused on basic research, the headwaters for the whole innovation ecosystem." The article goes on to say, "Today's challenges
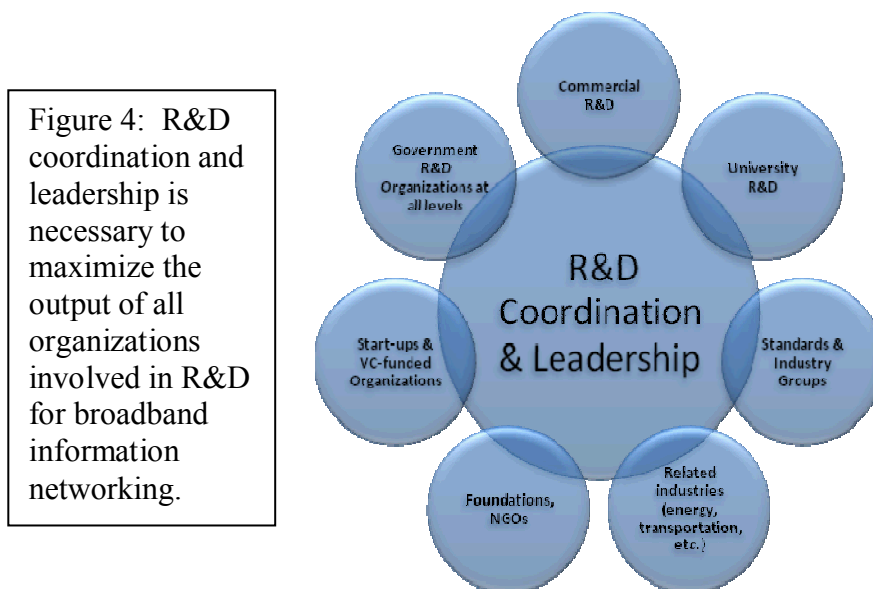

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Doug Adams, "It's 'patent-ly' obvious: U.S. needs better broadband," Knight Center of Digital Excellence, http://www.knightcenter.info/webapp-article-action/do.articleDetail/id.720/topicID.31, September 28, 2009.

require the government to unleash a series of highly focused, aggressively managed projects supported by a growing research investment in a dozen or more leading companies that in the aggregate reproduce the cumulative impact of Bell Labs, RCA Labs, Xerox PARC, and others."[13] We agree with these remarks and believe that our proposed combination of increased federal funding and an expanded R&D tax credit will provide a foundation for reinvigorating upstream basic and applied research.

We would further propose that a new organization be created to provide coordination, direction, and oversight for research in broadband and information networking. This organization – which we will call the Center for Broadband and Information Networking R&D simply for purposes of discussion – would be federally funded and chartered with maintaining our nation's competitiveness and productivity in broadband by managing and coordinating the broadband research portfolio. The Center would not have its own labs nor perform research projects, but would rather serve to oversee the nation's investment in broadband R&D by directing funding to private and public institutions and collaborative teams based on the national broadband roadmap. With more active direction and leadership, visionary goals can be set, inspiring the research community to propose high-risk, high-reward projects. Current drivers and incentives for both industrial and university researchers can favor less risky projects of an evolutionary nature, as opposed to potentially ground-breaking projects. Proactive leadership can limit fragmentation, ensure coverage of all areas and phases of the R&D spectrum, and actively guide funding into important areas.

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[13] Business Week, August 27, 2009, "Where Have You Gone Bell Labs?" by Adrian Slywotzky.

With the wide variety and diversity of organizations involved in this critical infrastructure, leadership and coordination are required not only for directing investments into promising areas, but also for creating interactions and synergies that will accelerate commercialization and its impacts on the ICT industry and all other industries that are supported by ICT. Coordination must span all relevant organizations of all sizes, private and public, industry and academic, critical to advancement of the industry. The need for coordination among federal government funders of networking research has been recognized and is currently addressed by the Federal Networking and Information Technology Research and Development Program.[14] This program is but a small step in the right direction, as much wider coordination and more proactive leadership and direction are needed among all of the critical constituencies as shown in Figure 4.

Figure 4: R&D coordination and leadership is necessary to maximize the output of all organizations involved in R&D for broadband information networking.

We would look to the proposed Center to provide strong and active leadership not only on defining important research directions, but also on program implementation,

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[14] See http://www.nitrd.gov/about/about_nitrd.aspx.

contracting, and administration and on addressing roadblocks to full and open collaboration and knowledge sharing. One of the difficulties that can hamper research work is a lack of data and information on which to test new ideas and to identify and modify the most promising concepts. Developing a workable contracting framework, including confidentiality, Intellectual Property protection, and limitation of liability is necessary so that, for example, organizations can share information about security threats, attacks, and possible response strategies without either increased risks of lawsuits or exposing vulnerabilities to criminal elements. We propose that the Center have a modest-sized permanent staff along with a body of rotating personnel from constituent and stakeholder organizations who work at the Center on limited term assignments. The rotating staff model is particularly important for effecting technology transfer which is, as the oft-quoted phrase says, 'a contact sport.' In fact, one key industrial R&D executive went on to say, "It (technology transfer) depends upon collaboration, teamwork, and interpersonal networking much more than fundamental research does."[15] With a combination of permanent and rotational staff the Center will be ideally situated to oversee, administer, and coordinate a dynamic and high-value research portfolio.

The Center should be directed by a high-level expert advisory council along the lines of the national technology council recommended by TIA[16]. This "Broadband Technology Council" would consist of senior executives and scientists and would provide direction to "define and guide strategic areas in [broadband technologies] that

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[15] Quote from Dr. Jim Mitchell, Director of Sun Labs; see
http://research.sun.com/features/tenyears/F3ttJB.html.
[16] TIA, "Investing in Telecom for Tomorrow's Innovations: The Case for Increased Telecommunications Research Funding," http://futureofinnovation.org/PDF/TIA%20Telecom%20Research%20Funding%20Final.pdf,

require further research critical to the future growth of the U.S. economy. Such a Council should include representatives from different sectors, such as government, academia, and industry." This Council would serve also as a forum for communication and the dissemination of ideas, information, developments, and solutions.

The Center and Council should establish high-level linkages to related industries such as health care, energy, public safety, and transportation, and also to international standards bodies and other international organizations. Broadband infrastructure is, by its very nature, an enabling infrastructure which benefits smart grids, e-Health, education, law enforcement, intelligent transportation, and many other industries. To fully and cost-effectively realize the benefits of a high-performance communications infrastructure for these verticals, collaborative research programs should be funded that bring together diverse participants in the ICT and other industries to address critical challenges through pre-competitive research projects. Not only are there important outstanding research problems, the solutions to which affect multiple industries, but there are also numerous, close interrelationships between these industries. Providing strong connections at a senior level among these industries will help avoid bottlenecks and ensure that advancements in one industry spur those in others. Government support for pre-competitive, collaborative R&D offers the advantages of reducing replication and promoting interoperability. Appropriate areas for this work include:

- Addressing wide-ranging challenges that impact multiple industries and sectors;
- Advancing the industry in ways that provide significant societal benefit but minimal market benefit;

- Performing the sometimes unglamorous research necessary to ensuring scalability and end-to-end performance; and,

- Reducing costs and sharing risks for expensive high-risk R&D ventures.

Lastly, we encourage the Center to establish and maintain active interactions with international research, development, and standards organizations working in telecommunications and broadband networking. These interactions should include participation by U.S. research teams in selected international programs where this is of value.

Key Areas for R&D

Achieving a high-performance America will require a nation-wide, high-speed broadband infrastructure that is trusted, usable, reliable, interoperable, survivable, scalable, robust, efficient, adaptable, secure, available, evolvable, open, dependable, fault-tolerant, maintainable, and inclusive. Accomplishing the development and deployment of this infrastructure – in an affordable and timely fashion -- will necessitate continued innovation across a wide range of diverse areas of science and technology. Broadband information and services delivery is fundamentally complex as it involves many different capabilities, technologies, policies, devices, organizations, and processes working in concert. The following list provides a 'baker's dozen' of the research areas we deem most important and beneficial.

Research Areas Addressing Access and Impact:

- Intuitive, tolerant interfaces and improvements in usability that will spur the adoption and use of beneficial broadband services for all citizens regardless of age, race, level of training, and disability status.

- Devices, interfaces, and services that support and connect all Americans easily and affordably – including the disabled, homebound, Veterans, and elderly.

- Mechanisms and systems that track and report the accuracy, balance, and representativeness of content, information and their sources, including techniques for providing data on digital rights and provenance of information that help improve the integrity, trust, and value of news and media.

- Increased ease-of-use for broadband services and applications to generate economic value by lowering barriers to adoption and use of broadband, by reducing training requirements, and by cutting costs to citizens and organizations of supporting applications and users; this includes not only research in user-centered design and next generation interfaces, but also work to make network services much more intuitive and tolerant of user behavior.

- Collaborative projects which bring together experts in ICT, energy, transportation systems, education, public safety, health care, and other industries to create innovative uses of broadband in machine-to-machine communications and automation, remote delivery of services, and integrated disaster planning and recovery; and to identify and address critical infrastructure dependencies and reliability requirements.

Research Areas Addressing Operability, Security, and Extensibility:

- Trusted networks that are more inherently secure and that, on an end-to-end basis, safeguard users' privacy; insure the security of information, applications, and transactions; protect against denial-of-service and other attacks; and provide useful and usable access controls so that sensitive digital information is available only for necessary and authorized use.

- Robust architectures, networks and services that are impervious to minor errors, that have high availability and dependability, that are self-healing, that detect and tolerate feature interactions and other faults, and that are survivable to rapidly restore critical services and applications.

- Smart, adaptable, scalable, and flexible systems and networks that expand in reach and capability to support advanced services, that gracefully evolve to accommodate new requirements and technologies, and that adapt without major disruptions or expense.[17]

- Advances in interoperability, standards processes, and open source models so that the national broadband infrastructure works seamlessly and with high-performance and quality across devices, domains, technologies, and networks — licensed and unlicensed — to support mission-critical applications in emergency response, disaster recovery, health and safety, law enforcement, homeland security, commerce and banking, and utility controls systems.

- Creation, implementation, and deployment of a broadband best practices clearinghouse to reduce information barriers for municipalities, agencies, business,

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[17] Also referred to as cognitive networking.

and non-profits that want insights into more effectively utilizing broadband infrastructure, or into broadband deployment or adoption projects.

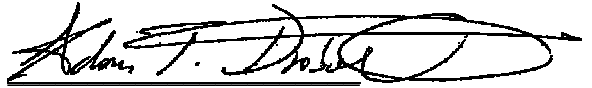<u>Research Areas Addressing Cost Reduction and Deployment:</u>

- Fundamental innovation in broadband networking technologies – fiber, coax, wireless, and satellite -- that provide significantly greater capacity and performance at significantly lower expenses.

- Advances in automation of network deployment (i.e., autonomous fiber-trenching or pole-climbing robots) to fundamentally lower deployment costs and of operations and management to more cost-effectively build-out and evolve the broadband infrastructure.

- Production and performance breakthroughs in electronics, devices, interfaces, and related technologies, including those used to support disabled users, which yield substantially lower prices for adopters.

CONCLUSION

For the foregoing reasons, Telcordia urges the FCC to consider our comments and recommendations. By adopting our recommendations, we believe that the Commission can position the United States to achieve world leadership in broadband networking for the future

Respectfully submitted,

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